

# AN EXPERIMENT UPON ELECTRIC FISH MADE BY GALVANI.\*

Translated from the *Revue Scientifique* by the Marchioness  
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Among the objects which are to be found in the *Musée Retrospectif*, is a little note book that once belonged to Louis Galvani. This note book, which has been kindly placed at our disposal by the Chevalier Auguste Mattioli, a great nephew of Galvani, contains autographic notes made by the illustrious forerunner of Volta, relative to some experiments performed upon torpedos in the year 1795, during a voyage to Sinigalia and Rimini, taken expressly by Galvani that he might study electric fish.

We find the following dates in the note book, 14th, 16th, and 17th of May, relating probably to Sinigalia, and that of the 19th of May to Rimini, where Galvani remained but two days.

The facts and considerations registered in the note book are partially to be found also in the fifth memoir addressed by Galvani to Spallanzani. But the whole has not been produced heretofore, and it will be a matter of some interest doubtless to learn that the autographic notes of Galvani contain passages which show us that in all probability he was the first to make observations relative to electric *polarization*. He would, perhaps, have carried the study further had not death interrupted his career on the 14th of December, 1798, when he was but sixty-one years of age.

The unpublished manuscript which I am going to produce does not detract from the merits of Gautherot, Ritter or any other *savants* who have given particular attention to the phenomena called by de la Rue *electric polarization*. It is no less interesting and curious, however, to be able to affirm that Galvani had observed them and distinguished them from other phenomena, four years before the pile was discovered.

In order to fully understand what I shall translate to you, it must be borne in mind that to Galvani muscular fibre represented a Leyden jar into which the nerve thread entered that played the rôle of conductor for the interior armor of the jar, while the exterior surface of the muscular fibre represented the outer armor of the small condenser. This hypothesis is advanced in Galvani's memoir entitled, *De viribus electricitatis in motu musculari, commentarium*, printed in Bologna, 1781.

Here now are the notes: no. 1, page 22.

"May 14-16, 1795.

"After a prepared frog has undergone several contractions upon the torpedo, if it is held by the feet with one hand, while a finger of the other hand is applied to its nerves, new contractions occur successively whenever the finger is separated from the nerves—that is to say, whenever the arc is interrupted.

"As I had made quantities of experiments in the ordinary manner without witnessing anything of the kind, I thought that in this case electricity was communicated from the torpedo to the frog, and had charged the little Leyden jars which I supposed were there."

No. 2, page 68.

"May 19, 1795.

"In operating upon two prepared frogs, whose nerves were detached from the spinal marrow, it happened that after they had been applied to the torpedo's back, and experienced several successive convulsions, particularly from shocks given directly by the torpedo, they contracted habitually when they were held by the feet with two fingers of one hand, or by a silken thread, while their nerves were touched by the fingers of the other hand, moistened by contact with the torpedo. The convulsions took place each time that the nerves ceased to be touched by the fingers, that is, whenever I interrupted the arc formed

by the two arms and the corresponding part of the thorax, which arc was applied at one end to the frog's feet and at the other to its nerves.

"This phenomenon lasted for some time and appeared more pronounced in the frog which had become convulsed by being applied merely to the torpedo's back without receiving any shock whatever.

"Once exhausted the phenomenon did not repeat itself, probably because the electricity from the torpedo having entered the nerves had weakened the muscular power of contraction.

"I have often used the same arc while experimenting upon numbers of frogs, but never before observed so many contractions produced so rapidly. It would not be unreasonable therefore, to suppose, that in this case the torpedo transmits a portion of its electricity to the frog and charges the little animal Leyden jars which exist in my imagination.

"It might perhaps be discharged again, produce a fresh charge and give rise to other contractions. The first supposition however, appears more probable.

"Whichever it may be, the entire modification occurs in the frog and not in the fingers or the hand which touch the torpedo. For having moistened the back of the hand which certainly did not come in contact with the torpedo, the result, on repeating the experiment, was precisely the same."

If I am not seriously mistaken, we have here actual phenomena of polarization provoked by the rapidity of the discharges from the torpedo (direct or indirect) across the nerves or muscles of the prepared frogs. The first observation of these facts is due to Galvani, although he employed no other instruments than these same frogs which had already made him familiar with the phenomena attributed to Volta to the contact of metals, and from which was soon to arise that wonderful apparatus called the Pile, whose marvellous development has been fully attested.<sup>1</sup>

## AN IMPORTANT CONTRIBUTION TO THE DOCTRINE OF CEREBRAL LOCALIZATION.

BY E. C. SPITZKA, M. D.

With the collapse of phrenology, an undue reaction set in against all attempts to undue functions in the convolutions of the human brain. The important anatomical theorization of Meynert, who taught that while the anterior zones of the brain were rather motor, the posterior and temporal lobes rather sensory in character, opened the path to the experimental inquiries of Hitzig who demonstrated the former truth by means of localized electrization in dogs, and thus suggested a rational distribution of simple functions in the organ of the intelligence, in no respect however comparable to the erroneous schematizations of Gall. The most recent and important contribution to this subject is entitled:

UNTERSUCHUNGEN UBER DIE LOCALIZATION DER FUNCTIONEN IN DER GROSSHIRNRINDE DES MENSCHEN, by Prof. Sigmund Exner, of Vienna.

<sup>1</sup> M. du Bois Reymond made a few remark upon the notes read by M. Govi. He wished to call attention to the fact that Galvani's experiments, although very interesting in themselves, are far from procuring a polarization in the actual sense of the word. All that really occurred was this: the frogs that gave no shock without metal, produced one after being exposed to the torpedo's discharges. This phenomenon could not be assimilated to polarization, that is to the production of secondary properties in the conductors by the fact of a primary current traversing these conductors. M. du Bois Reymond does not pretend to explain definitely the phenomena observed by Galvani. It is probable however that the frog's greatest sensibility to its own current was simply the effect of the immersion of the muscles and nerves in the sea water and mucus upon the torpedo's body. By this immersion the tendinous extremities of the gastrocnemius and the exterior of the femur would acquire the negativeness which belongs to them in a state of mechanical or chemical transverse section. That is, the muscular current would be increased in intensity. This according to M. du Bois Reymond, is the most probable explanation of the phenomenon mentioned in Galvani's note-book.

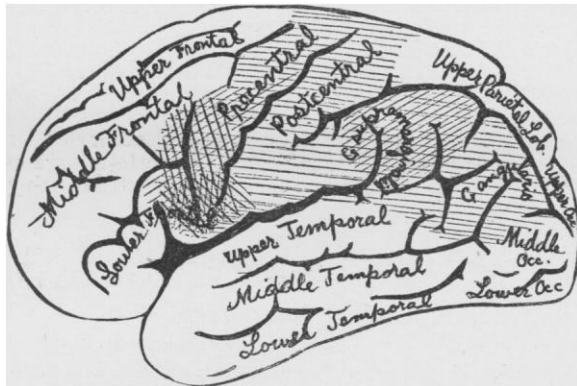
\*This communication was made by M. Govi before the Congress of Electricians, October 5, 1881.

This monograph constitutes an important *etappe* in our progress to a definite and reliable localization of the functions mediated through the cerebral cortex. Its author believing that the time has come for collating the numerous registered cases of circumscribed cortical lesions, has, in place of performing new experiments in this well-trodden field, contented himself with endeavoring to harmonize the often times conflicting observations of others, and at the same time sifted the wheat from the chaff. Over a thousand cases were collected by him, and of these a hundred and sixty-nine positive observations were found to comply with all the demands which a critical investigator would be apt to make.

Professor Exner has approached the difficult subject of which his work treats, by three different lines of research. The first follows the "method by negative cases," the second, "the method by percentage calculation," and the third "the method by positive cases." The latter method he considers the least reliable. The first method consists in marking on a diagram of a hemisphere, all those cases in which a cortical lesion occurred without producing a given disturbance, and inferring from this the presumable area within which the undisturbed function resides. With the second method, the area of a brain cast is subdivided by arbitrary lines into a number of squares. Of these the author made three hundred and sixty-seven, the smallest and most numerous being at the more important regions, such as the neighborhood of the Rolandic, and

a pitch-black color would designate the field with which paralysis of the arm was a constant symptom, less darker shades those in which it occurred in eighty, sixty and forty per cent. of the cases recorded, and very light shades for those with whose lesions, paralysis occurred in a still smaller percentage. This method proved of great value, inasmuch as it enabled the investigator to discriminate between what he happily terms the *absolute* and the *relative* cortical fields, the former being those whose lesions invariably produce a given phenomenon, the latter those whose lesions frequently, but not as constantly, produce the same result.

The third method is considered admissible only on the condition that not only a given prominent disturbance be marked down to a special field, with whose lesion it occurs, but that also all accompanying anomalies be registered with it. The site of a given centre can then be inferred, from the greatest accumulation of special foci. The reason why Exner considers this method as the most uncertain he illustrates by the following supposititious case. "Let us take for granted that the part of the *Gyrus fornicatus* adjoining the paracentral lobule, is the cortical field for the lower extremity. The part mentioned is but extremely rarely the seat of disease (there is but one case in my series, in which it was affected), the latter occurrence on the other hand is very frequent. Now, disease of the paracentral lobule, will, as can be inferred from other cases, also exert a

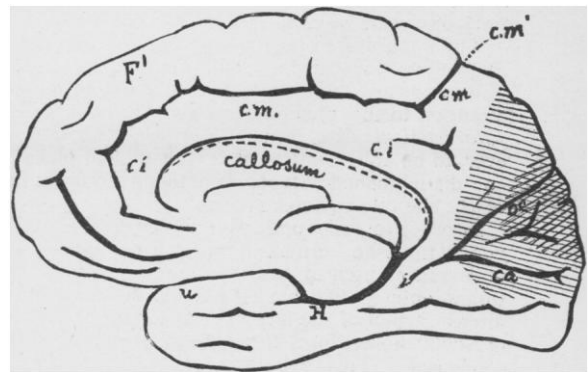


a. Diagram showing the cases of cortical lesion producing tongue-paralysis, left hemisphere.

Occipito-Parietal sulci. He then constructed tables, in which each of the arbitrary fields occupied a place, designated by its numeral, while in one column, the side of the hemisphere, in another the number of cases in which the field was involved, and in others the percentage of these cases, in which a given disturbance occurred are registered. For example, the record of "field 53" which is at the junction of the upper and middle thirds of the precentral gyrus and bordering the central fissure, reads as follows:

C	No. of Cases.	Facial Muscles.	Upper Extremity.	Lower Extremity.	Speech.	Muscles of Neck.	Muscles of Tongue.	Muscles of Eye-ball.	Tactile Disturbance.	Visual Disturbance.	No Disturbance.
On right side.	8	.88	.100	.63	..	.13	.13	.13	.13	.13	.00
On left side ..	22	.76	.100	.73	.14	.09	.14	.09	.09	.00	.00

Based on these tables Exner painted the squares on different casts or diagrams, with a dark color whose intensity decreased with the lesser constancy of the symptoms referable to that field. Thus on a given diagram,

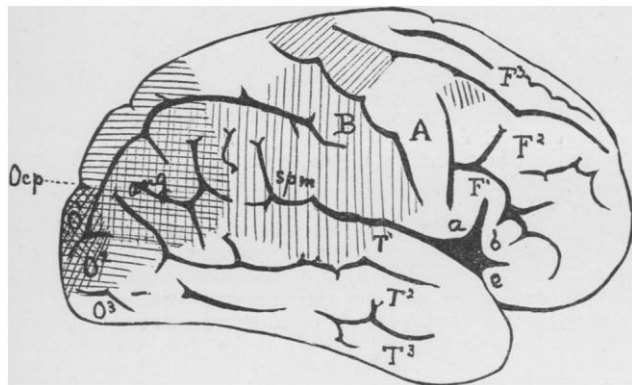


c. Same field on mesal face of right hemisphere.

disturbing influence on the neighboring gyrus. We will then register several, perhaps even many cases, in which injuries of the paracentral lobule are accompanied by disturbances of motility of the lower extremity, and from this conclude that the cortical field for the latter is in that lobule." He strongly protests against the unjustifiable assumption of narrow cortical centres on the basis of one or two isolated lesions, while ignoring the other symptoms co-existent with the one which is referred to that centre. An example of such an assumption is that by Landoosy who claimed on the basis of some (admittedly striking) cases, that the cortical field of the levator palpebræ was in the posterior part of the inferior parietal lobule. He endorses the criticisms of Nothnagel, but does not go to the extent of claiming as the latter does, that in order to justify the localization of a centre, the symptoms referred to it in a given case should be of chronic stability. He maintains that they may be evanescent, on the basis of the evanescent nature of the symptoms produced by cortical excision in dogs, and notably on the strength of the celebrated case recorded by Hitzig, of a dog in whom the removal of a cortical field, which just previously had been determined by electrization to innervate the anterior extremity, failed to produce paralysis, then showed paralysis on an additional incision at the operated region being made, from which he recovered after some weeks.

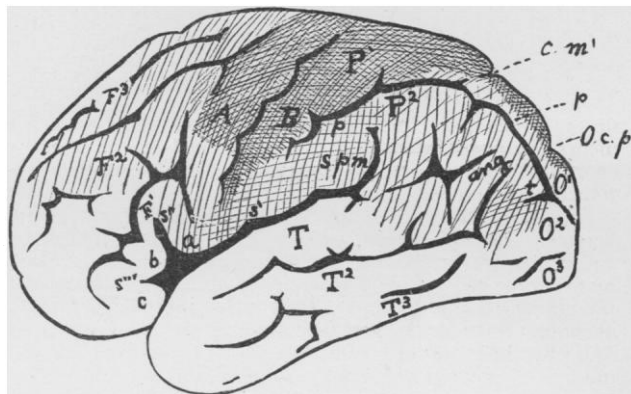
The author, after these provisional remarks, and a more detailed statement of his manner of marking the lesions, than could be properly recapitulated within the limits of this review, proceeds to describe what he terms the "cortical area of latent lesions" that is, the large area which *may* be the seat of a lesion without the occurrence of any motor or sensory disturbance. Remarkably enough this area is larger on the right hemisphere than on the left, a fact attributed by Exner, to the greater extent of the motor fields on the left side; aside from this, the respective areas, are, as might be anticipated, symmetrical. In the area of "latent lesions" there are degrees of latency, just as there are "absolute" and "relative" fields in the active fields, and while Exner includes all areas in which motor and sensory disturbances are not *necessary* results of lesions, under the designation latent, he does not intend to convey the impression that such symptoms may not be produced there. In this limited sense, the entire right hemisphere is latent, with the exception of the precentral and post-central gyri, the para-central lobule, and a strip of the convex surface as well as the ventral surface of the occipital lobe. Probably the latent area of the right frontal lobe would have turned out to be more limited, had Exner not included the case of an imbecile, in whom a lesion of the posterior ends of the three frontal gyri of the right side, failed to produce any paralysis or disturbances of sensation, "in the ordinary sense of the term." On the left hemisphere the latent fields occupy the cortical sur-

dratus, with possibly part of the cuneus. On comparing the area just mentioned with the other cortical fields derived from his studies, Exner comes to the conclusion that the field of the right arm is the largest of all the cortical areas. The absolute field of the posterior extremity on the right hemisphere consists of the para-central lobule, the upper third of the precentral, a lesser portion of the adjoining part of the post-central gyrus, and a few spots behind and below the lobulus quadratus. On the left hemisphere, it is very similar in extent, but includes in addition the greater part of the upper parietal lobule. Instead of occupying an insignificant portion of the post-central gyrus, it encroaches on the whole upper half, and is less marked on the precentral. In fact there is a general tendency of the left hemisphere field of the extremities to extend backwards as contrasted with the corresponding right field. Exner adds that if his tables could have been so compiled, as to show at a glance the extent of each of the lesions producing paralysis of the extremities, the greater "sensitiveness" of the field for the upper extremity as contrasted with that of the lower would have become evident. In other words, lesions of slight extent involving those areas common to both extremities, will frequently produce paralysis of the arm alone, while the leg is unaffected. The cortical field of the facial muscles is an absolute one only on the left hemisphere; it is merely relative on the right side, where it attains the greatest intensity, about  $\frac{1}{10}$  in the lower third of the post-



*b* Diagram of cases producing visual disturbance, convexity of right hemisphere.

face with the additional exception of the entire parietal and a greater portion of the occipital lobe. This encroachment on the latent field is due to the great development of the visual field and the greater posterior extension of the motor fields. The position of the gyrus fornicatus is in part very doubtful on account of the rarity of lesions of this locality. The cortical field for the right upper extremity consists of the para-central lobule, the precentral gyrus, with the exception of its lower-most portions, and the upper half of the post-central gyrus; it is an open question whether the anterior part of the lobulus quadratus, and a part of the gyrus fornicatus, may not have the same relation. The region indicated is an "absolute" cortical field, that is, it was thus far never found the seat of a lesion, when paralysis of the left arm was absent. Surrounding this area, there is a considerable "relative" field which extends over nearly the entire hemisphere. The absolute cortical field for the right upper extremity, that is the one of the left cerebral hemisphere, is larger, it includes the greater part of the upper parietal lobule, the upper two thirds of each of the central gyri, the para-central lobule, and very likely a part of the inner face of the occipital lobe. The relative field of "great intensity" occupies the posterior half of the upper frontal, nearly the whole of the middle and inferior frontals on the convexity, the upper part of the occipital lobe, and the lobulus qua-



*a*. Field of the upper extremity on convexity of left hemisphere.

central, and the lower half of the precentral gyrus, shading off to the posterior part of the middle and lower frontals, and the anterior part of the supermarginal gyrus. The left absolute field is a narrow streak belonging to the anterior part of the precentral gyrus opposite the end of the middle frontal, the relative field is symmetrical with that of the right side, the same tendency to a more posterior encroachment noticed in the case of the extremity fields, characterizes the left facial field. In the facial field, Exner found it impossible to differentiate the different muscular groups beyond the confirmation of the old observation that the palpebral orbicularis is only exceptionally disturbed by any cortical lesion.

The hypoglossal field is very difficult to establish; it appears to be relative on both hemispheres, nowhere exceeding  $\frac{1}{10}$ ; it is remarkable that this field is less intense on the left hemisphere than on the right. This fact, Exner endeavors, in our opinion, very plausibly to explain on the basis of Stricker's metaphor. Stricker compared the muscles of articulation to a well trained pair of carriage horses, driven with double reins, by two drivers, (the cortical centers of each side) in such a way that while both drivers or the right one alone directed them in their ordinary gait, the left one alone was capable of directing their finer evolutions. If we bear in mind that as far as the coarser movements are concerned, each driver chiefly watches the opposite horse, but the left one



After the announcement of these conclusions, the abstracts of one hundred and sixty-seven cases are given. Among those from whom these cases are cited, Bramwell, Charcot-Pitres, Furstner, Petrina, Nothnagel, Boyer, and Bourneville are notable for the large number of cases contributed by them to this list. A full and comprehensive literature of the whole subject concludes the volume, which is rendered one of the most attractive contributions to our modern physiological literature, by the addition of twenty-five excellent plates, many of which are colored, while others contain photographs.

There is but a single point which the author seems to us to have laid insufficient stress on, and which yet might have furnished many interesting suggestions in support of the kind of localization which he appears to us to have established. We refer to the wonderful correspondence between his areas and the areas of particular types of cortical structure. Thus the visual area corresponds in its distribution to the area in which Meynert describes his eight-layered cortical type to occur in the greatest purity. The diffusion of the motor centers appears to harmonize with the discovery of cortical nests of large pyramids outside of the area where Betz first located them. The identity in locality of tactile with motor areas harmonizes with the notorious coincidence of a granular cortical layer, suspected to be sensory by Meynert, with the largest presumably motor pyramids in the fourth layer of the five-layered cortical type. There are other views of Meynert which acquire a strong support from Exner's researches; aside from the confirmation of Meynert's visual area, the latter's "speech field" is not only re-established but extended by the cautious compiler and critic whose valuable monograph we regret not having the space to present to our readers in a fuller abstract.

#### BOOKS RECEIVED.

**VOLCANOES: WHAT THEY ARE AND WHAT THEY TEACH.** By JOHN W. JUDD, F. R. S. Appleton & Co., New York.

"Vulcanologists have only just commenced those series of exact and continuous observations which are necessary to determine the conditions that regulate the appearance of volcanic phenomena. The study of the laws of volcanic action is yet in its infancy."

This astonishing and undeniable statement concerning a class of magnificent phenomena which have excited the admiration and awe, and been interwoven with the religious hopes and fears of the most intelligent portion of our race from the beginning of time, is a revelation of the inchoate state of natural science, notwithstanding its boasted progress in certain narrow fields. Every step in the modern search and study of distant worlds has been gained in large part by the invention and application of some new instrument, such as the telescope and spectroscopy; and, in the same way, this new book on a very ancient subject, presents to us a similar anomaly in that one of the most efficient means for peering into the abysses of our own globe has been found in the use of the microscope. The merits of this excellent work must be obvious to the most cursory reader, so far at least as regards the fascinating nature of the subject, the clear and easy style, the avoidance of technical terms, and the use of familiar illustrations, wisely chosen in the main from a few historical and most thoroughly studied volcanic vents. To the expert as well, even in so limited and popular a condensation of the bulky literature of the subject, pleasure

will be imparted by the careful classification and in general correct exposition of the principal facts and generalizations thus far gathered, by the avoidance of dogmatic over-statement (e. g., of invariability of the order of eruption of lavas, pp. 198-200)—by the simplification of the relationship and nomenclature of rocks (e. g., Chapter ix, pp. 247-269, etc.), in quiet protest against the minute sub-divisions of the laboratory-lithologists of Great Britain, and especially of Germany,—and by the prudent brevity and caution with which the more difficult, and indeed as yet inscrutable, themes of the last two chapters are discussed. The attention of American geologists might be particularly invited to the consideration of the evidences (pp. 240-242, etc.) of the sub-aerial and explosive character of probably nearly all the trap-overflows on this continent, now often regarded as quiet submarine or sub-terrestrial injections; and the time is soon coming for the recognition of the true nature of enormous accumulations of aerial volcanic deposits, tuffs, lapilli, etc., *in almost every part of our continent*, in spite of their long disguise through metamorphism and consolidation.

There are certain distinctions of importance made by the author, however, with which many students of petrography, both in this country and abroad, will not agree. One of these is the unguarded definition of granite, gabbro, diorite, etc., as merely conditions of lava, "crystalline varieties in masses which have cooled slowly at great depths" (pp. 58, 260, 265, 322, etc.). That may be true in many instances, especially at the British localities, with which the author is most familiar, e. g., the Volcano of Mull (p. 142). The popular student should, however, be advised that the same rocks abundantly occur elsewhere, particularly in that part of our continent which lies east of the Mississippi, in forms which are very similar to these, but not at all to be confounded with lavas, their derivation being entirely and unmistakably from the metamorphism of sediments: e. g., the granitoid gneisses, gabbro-gneisses, and metamorphic diorites and diabases of the Eastern United States.

Again, the origin of the "red clay" which is found to cover the bottom of the ocean over its abyssal areas can be only in part assigned to the cause accepted by the author, the disintegration of volcanic dust and oxidation of their content of magnetite (p. 74); the studies of Thomson, Nelson, Buchanan and others have shown the high probability of its partial increment as an insoluble residue from the solvent action of the carbon dioxide in seawater upon the calcareous globigerina-ooze, etc.

The origin of the interesting filamentous variety of volcanic glass of the crater of Kilauea in Hawaii, called "Pélé's Hair," which is apparently attributed to the upward impulsion of particles of liquid glass into the air by the passage of steam (p. 71), is explained with more probability by Dana, through the conveyance and drawing out of such particles by the winds.

It is true that fine crystals and concretions of minerals of certain groups, especially leucite, the zeolites, agate, etc., owe their origin in general, directly or indirectly, to volcanic action (p. 148-9), but the most ardent Huttonian must confess that there is no prevailing connection between "great masses of fused volcanic rock" and the sediments which now enclose "diamonds, rubies, sapphires, emeralds, topazes, garnets," etc.: the list is characteristic of metamorphic strata, and the author has evidently pressed his point too far.

Exception may well be taken also to the little attention paid by the author to the remarkable volcanic chain in the West India islands, still comprising six active vents (p. 228), notwithstanding his recognition of the significant fact of the vast depths in the neighboring portion of the Atlantic, ascertained by the deep-sea soundings of the Challenger (p. 242). In very opposition to this fact and disregard of its meaning, he considers this volcanic group merely as a secondary branching chain of minor importance (p. 233), connecting the great band of volcanoes of